Note on the occurrence of Brookite in the Cleveland ironstone.

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THE references to the occurrence of the titanium dioxide minerals as rock constituents have been so recently summarized in the 'Mineralogical Magazine[1]' that it is unnecessary to repeat them, except to refer again to Mr. J. J. H. Teall's record of anatase in the Cleveland ironstone[2].

Wishing to procure some of these crystals, a pound of ore from the Main Seam at Upleatham mines was treated by the usual processes of solution, washing by decantation, and separation by heavy solution. The residue obtained was equal to 0·16 per cent. of the material taken, and consisted mainly of anatase, mostly in sharply developed pyramidal crystals, with some pyrites in nodular concretions, possibly in replacement of some of the oolitic grains, together with other minerals of derived origin, among which rutile and tourmaline were the most prominent.

But, most interesting, were a considerable number of crystals of brookite. This occurred in two forms:—

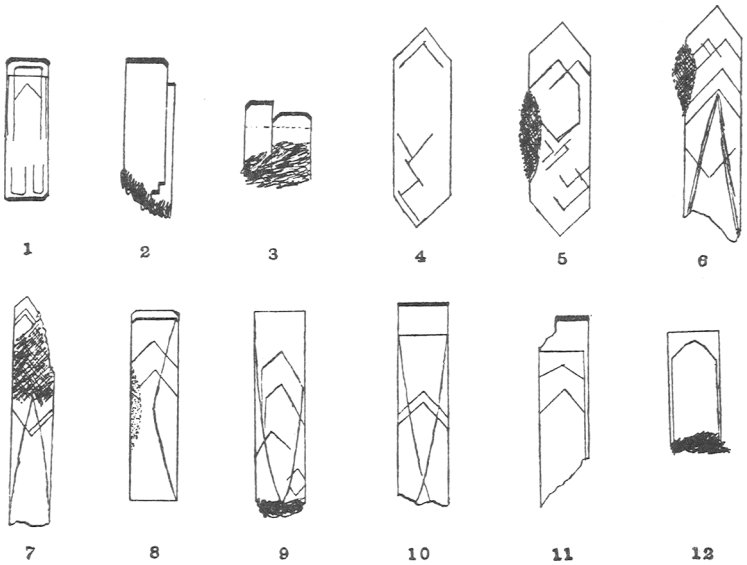
1. Thick, tabular crystals of deep reddish-brown colour, averaging about one-eighth of a millimetre in length by about one-fourth of that amount in breadth, though they sink to much smaller dimensions. They are occasionally doubly terminated, but usually show one end only with crystal-faces (figs. 1, 2, 3), the other end being broken off, or still attached to the material from which the crystals appear to have originated. In convergent polarized light the crystals well show the characteristic crossing of the optic axial planes for blue and red light. The absorption for light rays vibrating across the crystals is distinctly less than for those vibrating parallel to the length of the crystals.

2. The other habit in which the crystals occur is in extremely thin plates of the forms shown in figs. 4, 5, 6, 7. The external boundaries, as well as the lines marking the edges of the parallel growths, are very sharply

[1] J. B. Scrivenor, 1903, vol. xiii, p. 348.

[2] 'British Petrography,' 1888, plate 44, fig. 6, but not referred to in the text. The occurrence of anatase in the Cleveland ironstone was earlier noted by Mr. Allan B. Dick, and the crystals were measured by Professor W. H. Miller ('The iron ores of Great Britain,' Mem. Geol. Survey, 1856, p. 95).

defined. A few crystals are doubly terminated, but mostly they show only one termination, the edges of which meet at an acute angle; this angle has been measured in numerous cases, giving, e.g., 79½°, 80°, 81½°, 81°, 82°, 82°, 81°, so that, allowing for the fact that the crystals may not lie quite perpendicularly to the direction of vision, the angle appears



Crystals of brookite isolated from the Cleveland ironstone.

Fig. 1. Size of crystal: 0·100 × 0·025 mm. The central area is almost opaque.
Fig. 2. Size: 0·125 × 0·035 mm. Colour, deep reddish-brown.
Fig. 3. Crystal with lighter coloured extremity (above the dotted line).
Fig. 4. Size: 0·125 × 0·035 mm. Fig. 5. Size: 0·135 × 0·033 mm.
Fig. 9. Size: 0·245 × 0·042 mm. Fig. 10. Size: 0·108 × 0·025 mm.

(The slides from which these figures were drawn have been deposited in the mineral collection of the British Museum.)

to be about 82°. One crystal showed an obtuse termination of about 119° (fig. 11), while another showed one bounded by both forms in combination (fig. 12). The termination of 82° corresponds approximately with {065} or {*h*65}, and that of 119° with {035} or {*h*35}, but none of these are given in any recorded list of forms of brookite, though one of Thürach's figures[1] seems to have an angle identical with the acute one here mentioned. They polarize in bright colours, sometimes as low as

[1] The middle figure on p. 190 of Rosenbusch-Iddings, 'Microscopical Physiography of the Rock-making Minerals,' first edition, 1888.

those of the second order, but usually in the third and upwards; compensation takes place when the quartz-wedge is parallel to the length of the crystal. Pleochroism is slight, but distinct, the colour being reddish-brown for vibrations parallel to the length of the crystals, and yellowish-brown in the direction at right angles. There is frequently a darker core, like a rather lengthened 'hour-glass' (figs. 6–10); and the end is often of lighter colour than the rest of the crystal (fig. 3), even when this is not caused by differing thickness.

So far, I have been unable to obtain, with crystals of the second habit, a quite satisfactory figure in convergent polarized light, the nearest approach being a division of the field into indistinct areas of blue and red in their proper positions. But as to the identity of the two kinds of crystals I think there can be no doubt, for not only do these thinner crystals show all the other properties of brookite, but crystals occur which combine the forms of both, i. e., they have the rectangular termination of the one kind overlaid in parallel growth by the pointed form of the other (figs. 1 and 8–12).

In the hope that a fortunate chance might show the relation of the brookite to the anatase, three thin sections of the ironstone were prepared, but they yielded only negative results.

It may be mentioned that the now worked-out magnetite ore of Rosedale, in Yorkshire, yielded no brookite; that here the anatase occurred almost wholly in tabular crystals (parallel to the basal plane); and that, as in the other case, rutile occurred as a detrital constituent both in simple crystals and in twins.